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Specification as originally filed, with Application for Patent Serial No: 2,251,157, on  
October 26, 1998, by WILLIAM KEITH GOOD, RICK W. LUHNING AND  
KENNETH E. KISMAN, for "Process for Sequentially Applying Sagd to Adjacent  
Sections of a Petroleum Reservoir".

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1       **"PROCESS FOR SEQUENTIALLY APPLYING SAGD TO ADJACENT**  
2       **SECTIONS OF A PETROLEUM RESERVOIR"**

3       **ABSTRACT OF THE DISCLOSURE**

4       Steam assisted gravity drainage ("SAGD") is practised in a first section  
5       of a reservoir containing heavy oil. When production becomes uneconomic,  
6       steam injection into the first section is terminated. Non-condensable gas is  
7       then injected into the section to pressurize it and production of residual oil and  
8       steam condensate is continued. Concurrently with pressurization, SAGD is  
9       practised in an adjacent reservoir section. As a result, some of the residual oil  
10      in the first section is recovered and steam loss from the second section to the  
11      first section is minimized.

1

FIELD OF THE INVENTION

2 This invention relates to recovering heavy oil from an underground  
3 reservoir using a staged process involving, in the first stage, steam assisted  
4 gravity drainage, and in the second stage, non-condensable gas injection and  
5 reservoir pressurization.

6

BACKGROUND OF THE INVENTION

8 Steam assisted gravity drainage ("SAGD") is a process first proposed  
9 by R. M. Butler and later developed and tested at the Underground Test  
10 Facility ("UTF") of the Alberta Oil Sands Technology and Research Authority  
11 ("AOSTRA"). The SAGD process was originally developed for use in heavy  
12 oil or bitumen containing reservoirs, (hereinafter collectively referred to as  
13 'heavy oil reservoirs'), such as the Athabasca oil sands. The process, as  
14 practised at the UTF, involved:

15 • Drilling a pair of horizontal wells close to the base of the reservoir  
16 containing the heavy oil. One well was directly above the other in  
17 relatively close, co-extensive, spaced apart, parallel relationship.  
18 The wells were spaced apart 5 – 7 meters and extended in parallel  
19 horizontal relationship through several hundred meters of the oil  
20 pay or reservoir;  
21 • Then establishing fluid communication between the wells so that  
22 fluid could move through the span of formation between them. This  
23 was done by circulating steam through each of the wells to produce  
24 a pair of "hot fingers". The span between the wells warmed by  
25 conduction until the contained oil was sufficiently heated so that it

1 could be driven by steam pressure from one well to the other. The  
2 viscous oil in the span was replaced with steam and the wells were  
3 then ready for production;

4 • Then, converting to SAGD production. More particularly, the upper  
5 well was used to inject steam and the lower well was used to  
6 produce a product mixture of heated oil and condensed water. The  
7 production well was operated under steam trap control. That is, the  
8 production well was throttled to maintain the production temperature  
9 below the saturated steam temperature corresponding to the  
10 production pressure. Otherwise stated, the fluids being produced at  
11 the production interval should be at undersaturated or "subcooled"  
12 condition. (Subcool = steam temperature corresponding to the  
13 measured producing production pressure - measured temperature.)

14 This was done to ensure a column of liquid over the production well,  
15 to minimize short circuiting by injecting steam into the production  
16 well. The injected steam began to form an upwardly enlarging  
17 steam chamber in the reservoir. The chamber extended along the  
18 length of the horizontal portions of the well pair. Oil that had  
19 originally filled the chamber sand was heated, to mobilize it, and  
20 drained, along with condensed water, down to the production well,  
21 through which they were removed. The chamber was thus filled  
22 with steam and was permeable to liquid flow. Newly injected steam  
23 moved through the chamber and supplied heat to its peripheral  
24 surface, thereby enlarging the chamber upwardly and outwardly as

1                   the oil was mobilized and drained together with the condensed  
2                   water down to the production well.

3    This process is described in greater detail in Canadian patent 1,304,287  
4    (Edmunds, Haston and Cordell).

5                   The process was shown to be commercially viable and is now being  
6                   tested by several oil companies in a significant number of pilot projects.

7                   Now, the operation of a single pair of wells practising SAGD has a finite  
8                   life. When the upwardly enlarging steam chamber reaches the overlying, cold  
9                   overburden, it can no longer expand upwardly and heat begins to be lost to  
10                  the overburden. If two well pairs are being operated side by side, their  
11                  laterally expanding chambers will eventually contact along their side edges  
12                  and further oil-producing lateral expansion comes to a halt as well. As a  
13                  result, oil production rate begins to drop off. As a consequence of these two  
14                  occurrences, the steam/oil ratio ("SOR") begins to rise and continued SAGD  
15                  operation with the pair eventually becomes uneconomic.

16                  If one considers two side-by-side SAGD well pairs which have been  
17                  produced to "maturity", as just described, it will be found that a ridge of  
18                  unheated oil is left between the well pairs. It is of course desirable to  
19                  minimize this loss of unrecovered oil.

20                  In Canadian patent 2,015,460 (Kisman), assigned to the present  
21                  assignee, there is described a technique for limiting the escape of steam into  
22                  a thief zone. For example, if steam is being injected into a relatively  
23                  undepleted reservoir section and there is a nearby more depleted reservoir  
24                  section, forming a low pressure sink, there is a likelihood that pressurized  
25                  steam will migrate from the undepleted section into the more depleted section

1 - which is an undesired result. One wants to confine the steam to the  
2 relatively undepleted section where there is lots of oil to be heated, mobilized  
3 and produced. The Kisman patent teaches injecting a non-condensable gas,  
4 such as natural gas, into the more depleted section to raise its pressure and  
5 equalize it with the pressure in the relatively undepleted section. By this  
6 means, the loss of steam from the one section to the other can be curtailed or  
7 minimized.

8 The Kisman patent further teaches that pressurizing the more depleted  
9 section with natural gas has been characterized by an increase in production  
10 rate from that section, if the production well penetrating the section is  
11 produced during pressurization.

12

### SUMMARY OF THE INVENTION

14 In accordance with the present invention, a novel process is provided.  
15 for producing adjacent sections of an underground reservoir containing heavy  
16 oil. Each section is penetrated by one or more wells completed for SAGD  
17 operation, preferably one or more pairs of horizontal injection and production  
18 wells. The process comprises:

19 (a) injecting steam into the first section of the reservoir to practice  
20 SAGD and produce contained oil, until the steam/oil ratio rises  
21 sufficiently so that further production by SAGD from the section  
22 is substantially uneconomic;

23 (b) then reducing or terminating steam injection into the first section  
24 and injecting non-condensable gas into the section to maintain it  
25 pressurized;

9        Steps (b) and (c) constitute a post-steam window of oil production  
10      from the first section. Over time, oil production rate will drop off during  
11      window and eventually it will again become uneconomic to justify continuing  
12      to produce the first section. However it may still be desirable to continue  
13      maintaining pressurization in the first section to limit steam loss from the  
14      second section.

15 The process provides a strategy for sequentially producing adjacent  
16 sections across the reservoir. It takes advantage of gas pressurization to  
17 prevent steam leakage from a less depleted section undergoing SAGD to a  
18 mature, more depleted section. It also maximizes production from each  
19 section by subjecting it to sequential SAGD and pressurization production  
20 stages.

1                   DESCRIPTION OF THE PREFERRED EMBODIMENT

2                   In accordance with the best mode of the process known to the  
3                   applicants, it comprises:

4                   (a) directionally drilling one or more pairs of wells from ground  
5                   surface into a reservoir first section, to provide generally parallel  
6                   horizontal, co-extensive, spaced apart upper and lower well  
7                   portions extending through the section, and completing the wells  
8                   for SAGD production;

9                   (b) establishing fluid communication between the injection and  
10                   production wells of each pair by circulating steam through both  
11                   wells, to heat the span between the wells by heat conduction,  
12                   and then displacing and draining the oil in the span by injecting  
13                   steam through the upper injection well and opening the lower  
14                   production well for production;

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15                   (c) practising SAGD in the reservoir first section by injecting steam  
16                   through the injection wells and producing the produced heated  
17                   oil and condensed water through the production wells while  
18                   operating said production wells under steam trap control;

19                   (d) preparing a second adjoining section of the reservoir for SAGD  
20                   production by carrying out the provision of wells and establishing  
21                   fluid communication between the wells of each pair as in steps  
22                   (a) and (b);

11 In connection with practising steam trap control with wells extending  
12 down from ground surface and having riser and horizontal production  
13 sections, it is preferred to operate as follows:

14       • measuring the downhole temperature at the injection and  
15            production wells of an operating pair, using thermocouples;  
16       • establishing the temperature differential between the two wells and  
17            throttling the production well to maintain the differential at a  
18            generally constant value (say 7°);  
19       • monitoring for significant surges in vapour production rate at the  
20            ground surface production separator and for surges in steam  
21            injection rate; and  
22       • adjusting throttling to minimize the surges.

23 Otherwise stated, a generally constant liquid rate at the wellhead is  
24 maintained and the bottomhole production temperature is allowed to vary  
25 within a limited range.

1       The invention is characterized by the following advantages:

2       • additional oil is recovered from the mature wells during the gas  
3                    pressurization stage, while simultaneously reducing steam leakage  
4                    from the second reservoir section;

5       • use is made of the residual heat left in the mature reservoir section;  
6                    and  
7       • a finite steam-producing plant can be applied in sequence to a  
8                    plurality of adjacent sections of the reservoir, without severe steam  
9                    loss from a section undergoing SAGD to an adjacent depleted  
10                  section.

1           **THE EMBODIMENTS OF THE INVENTION IN WHICH AN**  
2   **EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS**  
3   **FOLLOWS:**

4           1. A method for recovering heavy oil from an underground reservoir,  
5   comprising:

6           (a)   injecting steam and producing heated oil and steam condensate  
7   by steam assisted gravity drainage ("SAGD") in a first section of the reservoir  
8   until it is substantially uneconomic to continue doing so;

9           (b)   preparing an adjoining section of the reservoir for SAGD;  
10          (c)   terminating or reducing steam injection into the reservoir first  
11   section;

12          (d)   injecting steam and producing heated oil and steam condensate  
13   by SAGD in an adjacent second section of the reservoir; and

14          (e)   concurrently with step (d), injecting a non-condensable gas into  
15   the first section to pressurize it and producing residual oil and steam  
16   condensate from said first section.

17  
18          2. The method as set forth in claim 1 wherein:

19           the first section is pressurized in step (e) to a pressure about equal with  
20   the steam injection pressure in step (d).

